Process for the Regeneration of Sodium Borate to Sodium Borohydride for Use as a Hydrogen Storage Source (New FY 2004 Project)

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Subcontractors: Air Products and Chemicals, Inc.; Princeton University

Objectives

- To develop an electrolysis process for the reduction of borates to borohydrides
- To conduct preliminary engineering studies of the electrolysis process developed

Technical Barriers

This project addresses the following technical barrier from the Hydrogen Storage section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

- Q. Regeneration Processes for Irreversible Systems

Approach

Under this project, Millennium Cell will collaborate with Air Products and Chemicals, Inc., a recognized industry leader in hydrogen technology, as well as Professor Andrew Bocarsly of Princeton University. This project provides a solution to the storage of hydrogen through cost effective use and production of a chemical hydride, sodium borohydride ($NaBH_4$). The team proposes to develop a novel $NaBH_4$ production process and pilot the process at a size suitable for engineering scale-up.

Chemical hydrides, particularly $NaBH_4$, have been proposed as effective hydrogen storage methods for a wide variety of applications in both distributed power generation and transportation applications. The hydrogen storage densities of sodium borohydride and its aqueous solutions meet the technical target of 6% hydrogen capacity set by DOE. The demonstrated advantages and benefits of $NaBH_4$ are known; however, regeneration and production systems warrant further study in order to bring $NaBH_4$ to widespread commercialization. Therefore, it is the goal of this project to determine the technical feasibility of a new synthetic method for producing $NaBH_4$ that improves significantly upon the current process. It is expected that an improved process will lead to $NaBH_4$-based hydrogen fuel systems being economically competitive with hydrocarbon-based fuels.

The storage capacity of $NaBH_4$ and the relative simplicity of its hydrogen delivery methodology make it possible to construct a hydrogen fuel system that allows a vehicle to achieve a 400+ mile range on a single fill-up without sacrificing conventional passenger space inside the vehicle. Sodium borohydride can be stored as an aqueous solution, adding to its advantage as a safe and convenient

carrier for hydrogen. Its performance characteristics on hydrogen delivery have been validated by Millennium Cell's proprietary Hydrogen on Demand^{TM} technology. Prototype testing indicated that the load following characteristics of hydrogen delivered from borohydride is essentially non-distinguishable from that of compressed hydrogen.

An important barrier to overcome in commercializing this technology is the current cost of sodium borohydride. The key to lowering the cost is the technical feasibility of a more energy efficient $NaBH_4$ synthetic process. The regeneration of $NaBH_4$ from sodium borates requires the input of a substantial amount of energy. In the existing commercial process, this energy input is manifested as the energy input required to produce sodium metal, which is used in large quantities in a subsequent chemical process to yield $NaBH_4$. In this proposal, we intend to explore the concept of hydrogen-assisted electrolysis for the reduction of sodium borates or both sodium borates and sodium hydroxide. Electrochemical reactions involving hydrogen often have the advantage of low overpotential and single step process operations; therefore, they are able to achieve higher overall energy efficiencies. If this project is successful, it will significantly advance hydrogen storage technology for transportation and other potential markets by lowering the cost while meeting the specific energy and density criteria set by the DOE.